COAMPS Simulations of the Coastal Atmosphere

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LONG-TERM GOALS

The long-term goal of this project is to improve our ability to understand and predict environmental conditions in the coastal zone.

OBJECTIVES

The objectives of this project are to conduct and analyze mesoscale model simulations of the coastal atmosphere using the Naval Research Laboratory's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS), to provide model-based atmospheric forcing fields to coastal ocean modelers, to compare COAMPS model results to scatterometer and aircraft observations and to other model results, and to investigate and quantify the response of the coastal lower atmosphere to sea surface temperature variations.

APPROACH

The approach used in this project is to combine numerical model results with in-situ and remote-sensing observations to understand and quantify physical processes in the coastal lower atmosphere and test their representation in mesoscale atmospheric models.

WORK COMPLETED

High-resolution, two-dimensional numerical simulations of offshore flow of warm air over cool air have been conducted using the COAMPS atmospheric model, with standard and modified TKE-based turbulence-closure schemes (Figs. 1,2). Flow variables from these simulations have been compared to observations of mean and turbulent quantities analyzed by Mahrt et al. (2001) and Vickers et al. (2001).

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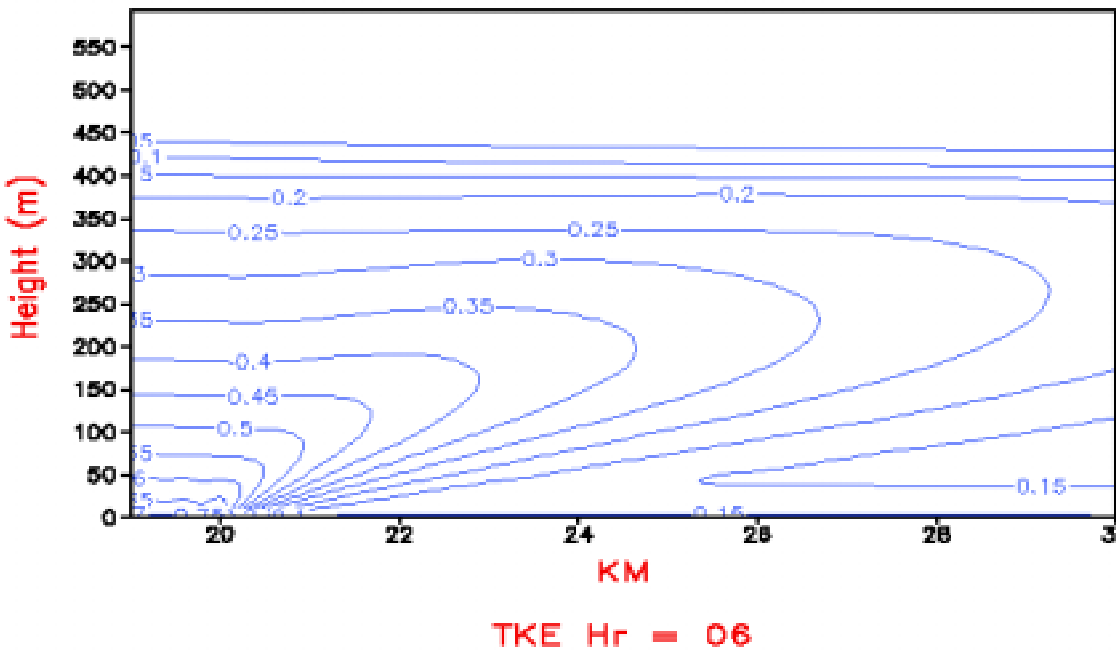

Figure 1. Contours of turbulent kinetic energy (m^2 s^{-2}) *vs. height and horizontal distance over the central portion of the model domain, at hour 6 of the simulation with constant* α. *The land-sea boundary is at 20 km.*

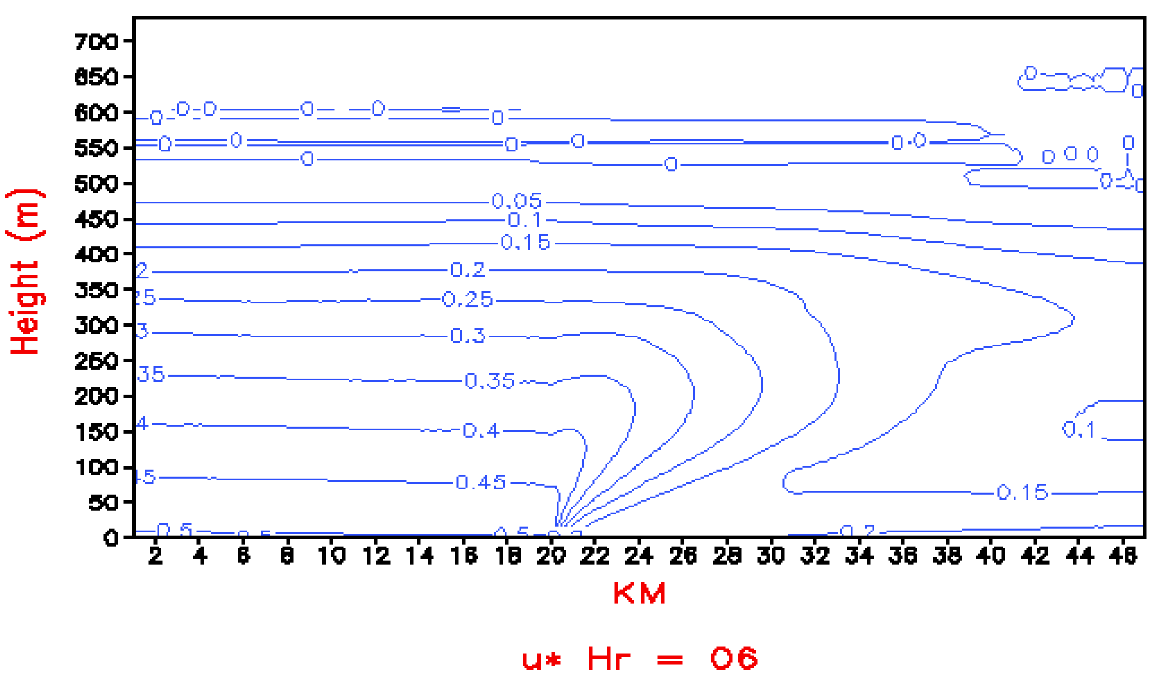

Figure 2. Contours of friction velocity u_* (m s^{-1}) *vs. height and horizontal distance over the entire horizontal extent of the model domain, at hour 6 of the model simulation with constant* α. *The land-sea boundary is at 20 km.*

The COAMPS atmospheric model has been implemented for the Oregon coastal zone and daily simulations have been conducted and archived for the period June 2000 to September 2002 (http://www-hce.coas.oregonstate.edu/~cmet/). Statistics of the resulting wind stress fields have been computed for the periods June through September 2000 and June through September 2001. Similar statistics for this period have been computed for the National Center for Environmental Prediction (NCEP) Eta model, an implementation of the University of Oklahoma Advanced Regional Prediction System (ARPS), and for observed wind stress fields from the QuikSCAT/SeaWinds scanning microwave scatterometer. A comparison of these COAMPS, ARPS, Eta, and QuikSCAT wind stress fields has been nearly completed.

RESULTS

The COAMPS simulations of warm offshore flow over cool water produce a decoupled turbulent boundary layer above a stable near-surface layer (Figs. 1,2), as in the observed fields (Vickers et al., 2001, Figs. 3,4). However, the offshore decay of turbulent kinetic energy (TKE) and friction velocity is different than observed, and the internal minima in TKE and friction velocity that occur in the model between the decoupled layer above and the stable near-surface layer below are not present in the observations. In addition, simulations with the standard boundary layer scheme, in which a mixing length parameter α depends on the signs of the surface fluxes, produce unphysical discontinuities in turbulent quantities throughout the planetary boundary layer at the land-sea boundary. A preliminary conclusion from this work is that current parameterizations appear unable to reproduce basic aspects of the observations of turbulent quantities on these scales and under these conditions.

The comparisons of scatterometer and model wind stress fields in the Oregon coastal zone show substantial variations in model wind stress estimates, partly due to differences in boundary layer parameterizations, and suggest that higher-resolution models can reproduce orographic effects more accurately, but may not improve temporal correlations with observed stresses in the coastal zone.

IMPACT/APPLICATIONS

The primary potential future impact of these results is on the design and use of prediction systems for coastal oceanic and atmospheric conditions.

TRANSITIONS

Wind stress fields obtained under this project are being provided to coastal ocean modelers (J. S. Allen, OSU) for use in dynamical and data assimilation studies.

RELATED PROJECTS

The ARPS and Eta components of this study and the summer 2001 aircraft observations are supported by the NSF project “COAST: Coastal Ocean Advances in Shelf Transport.” The QuikSCAT scatterometer component of this study is being conducted in collaboration with D. Chelton and M. Freilich (OSU), with support from NASA Grant NAS5-32965 for Ocean Vector Winds Science Team activities. Part of the research on the lower atmosphere response to sea surface temperature is being conducted in collaboration with L. Mahrt (OSU). Additional support for the research reported here has been provided by the ONR project “Predictability and Dynamics of Geophysical Fluid Flows.”

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